No. 1. *Descriptions of Bolca Fishes.* By C. R. Eastman.

There are two principal sources of information in regard to the marine fish fauna of the Eocene period, leaving out of account the minor evidence that is presented by detached hard parts, such as teeth and other fragmentary remains. The first of these, which is at the same time the most important and historically the most interesting, is that furnished by the tolerably abundant skeletons occurring in the fissile limestone of Monte Bolca and Monte Postale in northern Italy. The other is that association of ichthyic remains which is known from the nearly equivalent horizon of the London Clay.

These two faunas fortunately supplement each other to a considerable extent, one of them making us acquainted with the large variety of forms which flourished during the later Eocene, and the other supplying us with important anatomical details. For the conditions of preservation in clay beds are obviously very different from those which are peculiar to limestone. Calcareous sediments are more compact; and where pressure and subsequent hardening occur, bodies which are not absolutely rigid, like the skeletons of vertebrates, or even the outer covering of chelonians and crocodilians, are liable to become compressed and flattened out. Hence, as a general rule, the parts belonging to either side of the body in fishes become squeezed together and confused when preserved in limestone, and the pliant head-bones become more or less distorted and displaced. This is almost invariably the case with the fishes from Monte Bolca, and for a correct understanding of the cranial osteology we must turn to the uncrushed skulls from Sheppey and elsewhere.

The London Clay fauna,[1] however, is not nearly so rich as the Italian, either in point of numbers or variety; and it is accordingly the latter which provides us with the principal data for comparing the ichthyic representation of Eocene and modern times. Comparisons of this nature and of detailed structural modifications are of the very greatest importance, since by their means we are able to trace the direction and

[1] Agassiz, L., Report on the Fossil Fishes of the London Clay (Rept. Brit. Assoc. Adv. Sci. pp. 279–310, 1845).

extent of variation and specialization that has been going on in certain groups during this interval. But the most striking fact which arrests our attention is not that variation should have advanced at such a slow rate since Eocene times as it apparently did, but that this process should have been quickened by such a sudden and enormous acceleration as took place at the dawn of the Tertiary system. Cretaceous forms pass away, leaving only here and there a few moribund survivors (*e. g. Pycnodus, Palaeobalistum*, etc.) in the Eocene, their place being taken by a host of modern types which appear for the most part absolutely unheralded. Not only does the Eocene fish fauna bear an overwhelmingly modern aspect, but many of its types are as highly specialized as they are to-day; and forms which at the present day are widely aberrant have representatives at least as far back as the Middle Eocene. It is evident that an "expression point" (to us Cope's apt term) was reached in the evolution of ichthyic life exactly corresponding to, and contemporaneous with that which is so well recognized in mammalian life, although the cause of the phenomena is in each case unknown.

The literature of Bolca fishes is extensive, and material from the typical locality has become distributed throughout the principal museums of the world. Nevertheless, the authentic specimens which have served either for the establishment of species, or for extending our knowledge in regard to them, are preserved in comparatively few institutions. These are the only reliable standards we have to refer to in cases where the synonymy is confused; and as such cases are numerous, it is of importance to systematists to know where these standards are preserved and may be consulted for study. In the sequel, therefore, a list is given of all the type and figured specimens belonging to the largest single collection of Bolca fishes which at present exists. In the following brief historical summary it is hoped that some facts have been brought together relating to the study of this fauna which shall be of service to investigators.

1. Old Collections, and Early Studies of Bolca Fishes.

Although the priority of the Italian school of geology and palaeontology amongst those of other nations is clearly established, the share contributed by fossil vertebrates towards stimulating inquiry has been less generally appreciated. For this reason it may be profitable to cast a retrospective glance over the formative period of these branches of

natural science, a period coëval with the literary reawakening in Italy. We need not, however, extend our survey so far back as to include the detached statements or speculations of classic authors, or even post-Augustan writers, such as Tertullian and Pomponius Mela, for, familiar as the ancients undoubtedly were with the occurrence of fossils, they do not appear to have been seriously concerned in attempts to account for their origin, nor did their views serve to enlighten subsequent progress. *Per contra*, the doctrines of Aristotle, followed blindly or enlarged upon by scholastic writers during the middle ages, acted as a positive hindrance. Minds which could accept without difficulty Aristotle's ideas of spontaneous generation were free to admit that mineral matter could take on of itself any conceivable shape, even mimicking animate forms. If living plants and animals could produce themselves, why not fossils, as readily? Avicenna,[1] for instance, most brilliant luminary of the Arabian circle of sciences in the tenth century, and whose *Canon Medicinae* remained the principal medical authority throughout the middle ages, proposed a *vis lapifidica*, and following him in the thirteenth century Albertus Magnus[2] affirmed his *virtus formativa*. At a still later period a "World-Spirit," or *Archaeus*, was predicated by Bauhin, and Libavius held that fossils sprang from germs or seeds, like living beings. Glimmerings of a spirit of experiment and observation are rarely in evidence before the fourteenth century. Until about this period nature-study in Europe continued at an extremely low ebb, Greek and Latin scientific works were unread in the original, and untranslated into the vulgar tongue, and popular concepts of natural history were perverted by the bestiaries.

Fourteenth Century. In Cecco d'Ascoli (1257–1327),[3] the ill-fated author of *l'Acerba*, and sometime professor of philosophy in the University of Bologna, we discover a man of remarkable erudition and

[1] *Cf.* Wüstenfeld, F., Geschichte der arabischen Aerzte und Naturforscher, nach den Quellen bearbeitet. Göttingen, 1840.

[2] Sighart, J., Albertus Magnus, sein Leben und seine Wissenschaft, nach den Quellen dargestellt. Regensburg, 1857.

[3] Popular name for Francesco Stabili of Ascoli, whom Petrarch honored with a sonnet beginning, —

"Tu se 'l grande Ascolan che il monde allumi."

He has been made the subject within recent years of a thoughtful essay by Welbore St. C. Baddeley, and of a historical romance by Pietro Fanfani (*Cecco d'Ascoli, Racconto storico del secolo XIV.* Leipzic, 1871). *L'Acerba*, which was the immediate cause of the author's death, passed through a score of editions between 1473, the date of the earliest, and 1546. The latest bears date of 1820, at Venice.

varied abilities, in many respects far ahead of his age. The work by which he is best known, an encyclopaedic poem of moderate literary merit, contains a vast number of observations on all manner of things natural and supernatural, in which the veritable and mythical are curiously blended. In Book I., Chapter viii. of *l'Acerba*, which is devoted to thunder, lightning, meteorites, earthquakes, and other physical phenomena, mention is made of the occurrence of fossils, although no definite explanation of their origin is undertaken, as has been claimed by Libri and others. Considering the period in which he wrote, we must admit Cecco to have been a first-rate observer, a good reasoner, and less credulous in his judgments than many of his predecessors and contemporaries. Caustic envy of Dante is conspicuous in various parts of his poem, especially in the concluding passage of Book IV., from which the following lines are taken: —

> "Quì non se canta al modo dele rane,
> Quì non se canta al modo del poeta
> Che finge imaginando cosse vane;
> Ma quì respiende e luce onne natura,
> Che a chi intende fa la mente lieta;
> Quì non se regna per la selva oscura."

Less a stranger to fame than Cecco is Giovanni Boccaccio, "prince of story-tellers" (1313–1375), one of whose early amusements consisted in gathering fossil shells near his home in the Valdelsa, hard by Florence. Unusually intelligent and well educated himself, he deplored the prevailing ignorance of his age, and aided largely in reviving the study of classic literature in Italy. Amongst his more serious Latin works is a Geographical Dictionary,[1] a laborious but indiscriminating compilation,

[1] De Montibus, Silvis, Fontibus, etc., supposed to have been written about 1373. The passage on *Elsa fluvius* (q. v.) occurs on p. 456 of the Basle edition, 1589. *Cf.* also, by the same author, *Commento a Dante, Lezione LII*, in Vol. II., pp. 367–369, of the Milan edition, 1863.

On Boccaccio and the extent of his information, the following may be consulted: Hortis, A., Studj sulle opere latine del Boccaccio. Triest, 1879. — Koerting, G., Der Umfang des Wissens Boccaccios, in his Geschichte der Litteratur Italiens, Vol. II. Leipzic, 1880. — Landau, M., Giovanni Boccaccio, sein Leben und seine Werke. Stuttgart, 1877. — Libri, G., Histoire des sciences mathématiques en Italie, Vol. III. Paris, 1840. — A list of the older writers consulted by Boccaccio in the compilation of his *De Montibus*, etc., is published in Boll. Soc. Adriat. Sci. Nat., Ann. III. pp. 62–114.

On Dante as a naturalist, see Holbrook, R. T., Dante and the Animal Kingdom, New York, 1902.

in which he refers to the occurrence of fossils, and agrees with Pomponius Mela (whose *Cosmography* he quotes) in considering them as having belonged to living bodies. A passage is also said to occur in Book VIII. of the *Filocopo*, by the same author, in which fossils are mentioned, and the inference is drawn from them that the land had been submerged beneath the sea; but Brocchi,[1] who is authority for this statement, appears to have been mistaken in his reference.

Sixteenth Century. Very few Cinquecentisti appear to have inquired into the significance of fossils. The first to claim our attention is Alexander ab Alexandro (1461–1523), a learned Neapolitan jurisconsult, concerning whom little is known save for personal statements interjected amongst a mass of miscellaneous information in his *Dies Geniales*.[2] In Book V., chapter ix., of this peculiar work, which first appeared at Rome in 1522, the author recalls having seen in the mountains of Calabria, at a considerable distance from the sea, divers sorts of marine shells heaped together and embedded in a variegated hard marble, so that they formed one mass: "*quas quidem ossea et non lapideas esse, et quales in litoralibus vadis inspicimus, facile erat cernere*," as he remarks. He refers to the statement of Herodotus[3] concerning the presence of marine shells in the hills of Egypt and over the Libyan desert, from which the Greek geographer had inferred that the sea formerly covered that whole region; and a like explanation is applied by him to Calabria.

According to Brocchi and Lyell, both of whom have furnished excellent accounts of the development of geological science in Italy, Alessandro anticipated by a long interval the theory advanced by Burnet and Whiston in England, which explained the waters formerly covering the land as having been drawn off in consequence of a change in the inclination of the earth's axis of rotation. But such a theory implies an understanding of the Copernican cosmogony, which Alessandro certainly did not possess, and as no such suggestion as is attributed to him can be found in the *Dies Geniales*, the statement is probably an error. Nevertheless, Alessandro is deserving of credit for

[1] Brocchi, G., Discorso sui progressi dello studio della conchiologia fossile in Italia, prefixed to his *Conchiologia Fossile Subappenina*, Vol. I. p. iv. Milan, 1814. Other early references to petrifactions are given by G. Lami in his Hodoeporicon of Chariton and Hippophilus (Deliciae Eruditorum, Vol. X., p. 43, *passim*). Florence, 1741.

[2] Alexandri ab Alexandro, Genialium Dierum, libri sex. There is a Paris edition of 1589, and a Leyden edition of 1673, in two volumes.

[3] History, Lib. II. cap. xiii.

having recognized the true nature of fossils, in despite of the popular notions that they were relics of the Scriptural deluge, or sports of nature generated within the solid rock through the operation of some occult force, or through the fermentation of a *materia pinguis*.

Throughout the sixteenth and seventeenth centuries the nature and origin of fossils remained a favorite topic of discussion. In the frequent and often vexed disputes of this period are to be observed on the one hand the influence of ecclesiastical prejudice, the Church claiming ability to explain all things, and possessing means of proved efficacy for compelling the acceptance of her views; and on the other hand the persistency of Aristotelian doctrines mingled with rank superstition. Such was the infertile soil into which the method of experiment and observation endeavored to send its roots. A tender plant in the beginning, its first green leaves withered, and during the long warfare between science and theology its growth was retarded. Concerning the methods in vogue during the period we are considering, it has been aptly remarked by Lyell[1] that "the system of scholastic disputations encouraged in the Universities of the middle ages had unfortunately trained men to habits of indefinite argumentation, and they often preferred absurd and extravagant propositions, because greater skill was required to maintain them; the end and object of these intellectual combats being victory and not truth. No theory could be so far-fetched or fantastical as not to attract some followers, provided it fell in with popular notions."

In the midst of such conditions as these it is pleasing to note the appearance of two men of remarkable insight, whose vision was in no wise clouded by the prevailing atmosphere of superstition and dogmatism. The first whom we have to consider is that versatile and brilliant genius, Leonardo da Vinci (1452–1519), of whom Humboldt remarked that "he was the first to start on the road towards the point where all the impressions of our senses convey the idea of the Unity of Nature." His clear exposition of the manner in which fossils have become preserved in the rocks offers a refreshing contrast to the prevailing views of the age, and although noticed by Humboldt,[2] Lyell and others, his remarks

[1] Lyell, C., Principles of Geology, I. chap. iii. London, 1834.

[2] Humboldt, A. von, Cosmos, II. chap. viii. Stuttgart, 1845. — Libri, G., Histoire des sciences mathématiques en Italie, III. Paris, 1840. — Lyell, C., Principles of Geology, I. chap. iii. London, 1830. — Raab, F., Leonardo da Vinci als Naturforscher, in Virchow and Holtzendorff's Sammlung gemeinverständl. Vorträge, ser. 15, p. 504. Berlin, 1880. — Ravaisson-Mollien, C., Les manuscrits de Léonard de Vinci. Manuscrits *F* et *I* de la Bibliothèque de l'Institut. Paris, 1889. — Richter,

have not attracted the attention amongst geologists and palaeontologists which they deserve. An idea may be formed of the nature of his observations from the following extracts, translated literally from his published manuscripts: —

"All marine clays still contain shells, and the shells are petrified together with the clay. From their firmness and unity some persons will have it that these animals were carried up to places remote from the sea by the deluge. Another set of ignorant persons declare that Nature or Heaven created them in these places by celestial influences, as if in these places we did not also find the bones of fishes which have taken a long time to grow; and as if we could not count, in the shells of cockles and snails, the periods of their growth, as we do in the horns of bulls and oxen." — *Leic. MS.* 10 *a.*

"And if you were to say that these shells were created, and were continually being created in such places by the nature of the spot, and of the heavens which might have some influence there, such an opinion cannot exist in a brain of much reason; because here we find [lines denoting] annual growth numbered on their shells, and there are large and small shells to be seen which could not have grown without food, and could not have fed without motion, — and here they could not move." — *Leic. MS.* 9 *b.*

"As to those who say that shells existed for a long time and were formed at a distance from the sea from the nature of the place and of the cycles, which can influence a place to produce such creatures, — to them it must be answered: such an influence could not place the animals all on one level, except those of the same sort and age; and not the old with the young, nor some with an operculum and others without their operculum, nor some broken and others whole, nor some filled with sea-sand and large and small fragments of other shells inside the whole shell, which remained open; nor the claws of crabs without the rest of their bodies, nor the shells of other species adhering to them like animals which have moved about on them, since the impressions of their tracks still remain on the outside, after the manner of worms in the wood which they ate into. Nor would there be found among them the bones and teeth of fish which some call arrows and others serpents' tongues, nor would so many portions of various animals be found all together if they had not been thrown on the sea-shore." — *Leic. MS.* 9 *a.*

J. P., The Literary Works of Leonardo da Vinci, compiled and edited from the original manuscripts, II. chap. vi. London, 1883. — Uzzielli, G., Leonardo da Vinci e le Alpi. Turin, 1890. — Venturi, G. B., Essai sur les ouvrages physico-mathématiques de Léonard de Vinci. Paris, 1797. — Whewell, W., History of the Inductive Sciences, II. London, 1847. — White, A.D., History of the Warfare of Science with Theology, I. New York, 1896. The most sumptuously published of all Leonardo's writings is the *Codex Atlanticus* of the Ambrosian library in Milan, which has recently been reproduced in facsimile under the auspices of the Regia Accademia dei Lincei.

"*On Shells in the Mountains.* — And if you were to say that Nature has formed the shells in the mountains through the agency of the constellations, how will you explain it that the constellations create shells of divers species and of different ages in the selfsame spots? . . .

"*On Leaves.* — How will you explain the multitudinous leaves of different species solidified in the rocks high up in the mountains, and sea-weed commingled with shells and sand? And likewise you will see all [sorts of] petrifactions together with fragments of marine crabs, commingled with these shells." — *MS. F, folio* 80, *a*, *b* (*circa* 1510).

With the exception of the last fragment, which has been inaccurately paraphrased by Venturi, Lyell, and others, the above passages have not been noticed in geological literature. How far Leonardo's ideas are reflected by the commonly current paraphrase referred to may be seen on comparing it with the original text, a literal transcript of which follows: —

"*Denichi nemonti.*

"Essettu vorai dire linichi esserprodutti dalla natura inessi monti mediante leconstelatione per qual uia mosterai tal constellatione fare li nichi di uarie grandeze i eddi uersè eta edi uarie spetie nun medismo sito ——

"*Delle fogle.*

"Cone [Come] proverrai ilgrandissimo numero di uarie spetie di foglie congelata nellei *pietre* alti sassi di tal monti ellaligha erba dimare stande a diacere mista con nichi ecosiuderi onni cosa petrificato insieme congranche marini rotti inpezi etramezati tu essi nichi."

The second notable sixteenth-century personage whose opinions concern us is Girolamo Fracastoro, or in the more usual scholastic form, Hieronymus Fracastorius (1483–1553) of Verona, famous as physician, poet, and astronomer. A statue erected to his memory a few years after his decease attests the esteem in which he was held by his fellow-townsmen, and the eulogies pronounced upon him in foreign lands indicate a widespread recognition of his ability. Through the partiality of an enthusiastic fellow-countryman,[1] he has been allotted little short of an apotheosis, but the most trustworthy judgment is probably that of Libri, which is as follows: "Un seul nom, celui de Fracastoro, domine à présent les noms de tous ces astronomes italiens. Il fut célèbre par la profondeur et la variété de ses connaissances. De Thou, qui, dans son histoire, en a fait un magnifique éloge, dit que Sannazar s'avoua vaincu par les vers latins du médecin de Vérone. Il fut bota-

[1] Lioy, P., Linneo, Darwin, Agassiz nella vita intima. Milan, 1904.

niste, philosophe, et mathématicien, et, cultivant des sciences si diverses, il s'illustra dans toutes." [1]

Fracastoro resembled his illustrious contemporary Leonardo in his ability to deduce sound conclusions from observed facts, and in his habit of appealing directly to nature rather than to authority for answer to the problems confronting him. His opinions in regard to the nature of fossils, a variety of which were brought to his attention during the reconstruction of a citadel in Verona in 1517, are set forth very clearly in a description of the Calceolarian Museum,[2] a work frequently referred to by the older writers, and also in an historical account of Verona by Torello Saraina.[3] Fracastoro ridicules the notion that fossils are the reliquiae of the Mosaic deluge, or were formed within the rocks through the agency of a plastic force, and states his reasons for believing them to be the remains of plants and animals which inhabited the sea at a period when the continents were submerged. Had these sensible views been heeded, much useless discussion which continued throughout the succeeding two centuries would have been avoided.

A brief notice concerning the fossil fishes of Monte Bolca, the earliest in which they are specifically referred to, was inserted by the celebrated botanist Mattioli [4] in his fourth edition of the *Materia Medica* of Dioscorides, which he commentated and illustrated in 1552. He also quotes the statements of Polybius, in Book XXXIV. of his History, re-

[1] *Op. cit.*, II. p. 101.

[2] Chiocco, A., and Ceruti, B., Musaeum Franc. Calceolari iun. Veronensis. Verona, 1622. The passage entitled "Magni Fracastorii Sententia de proposita quaestione," which occurs on p. 407 of this work, is quoted *in extenso* by Vallisneri in his *De' corpi marini che su' monti si trovano* (Venice, 1721), and is referred to by various other authors prior to Lioy. A figure evidently of *Holocentrum macrocechalum* is given on p. 428 of this work.

[3] Saraina, T., De Origine et Amplitudine Civitatis Veronae. Verona, 1530.

See also on Fracastoro the following: Barbarini, E., Girolamo Fracastoro e le sue opere. Verona, 1894. — Caverni, R., Storia del metodo sperimentale in Italia. Florence, 1893.— Holden, E. S., The Precursors of Copernicus (Pop. Sci. Monthly, LXIV. p. 316), 1904. — Lioy, P., Fracastoro e le sue idee divinatrici della Paleontologia (Atti R. Istit. Veneto, ser. 7, IX. p. 1098), 1898. — Meneghini, G., Dei meriti dei Veniti nelle Geologia. Pisa, 1866. — Menken, O., De vita, moribus, scriptis meritisque H. Fracastori Veronensis. Leipzic, 1731. — Omboni, G., Cenni sulla storia della Geologia. Padua, 1894. — Stoppani, A., Della preminenza e priorità degli studj geologici in Italia. Milan, 1868.

[4] Mattioli, P. A., Commentarii secondo aucti, in libros sex Pedaci Dioscoridis de Medica Materia, 4th ed., Venice, 1552; 5th, *ibid.*, 1558. The reference occurs in the Introduction to Book V., and is wanting in earlier editions of this work.

garding the "subterranean fish" of Narbonne and the views of earlier writers on the nature of fossils in general.

About this time interest became awakened in the formation of natural history collections, first in Italy, where zoölogical gardens had long since been introduced, and afterwards generally throughout Europe. One of the earliest and at the same time most extensive, was the museum founded at Verona in 1572 by Francesco Calceolari, which contained a number of Bolca fishes, and was the fruitful source of several publications. Ulisse Aldrovandi (1522–1607), a noted scientist and professor at the University of Bologna, brought together a large private collection, out of which grew eventually the Public Museum of Bologna, and descriptions of his minerals and fossils were published some years after his death.[1] In 1574 an elaborate description was prepared by Mercato, but not published until nearly a century and a half later, of the Vatican collection of minerals, fossils, and antiquities which had been brought together under the auspices of Pope Sixtus V. The priestly author, however, was content to believe that not only fossils, but even ancient pottery and inscriptions were mineral concretions which had assumed their shapes through the influence of celestial bodies.[2] Agassiz contemptuously remarks of this work that it is a "compilation sans valeur et sans goût." The physician Olivi of Cremona, who described in 1584 the fossils contained in the Calceolarian Museum,[3] was likewise prejudiced in regarding them as *lusi naturae*. Nevertheless his work was deemed worthy of being reprinted nine years later, and new illustrations of the same museum appeared in 1622, at the hands of Ceruti and Chiocco, as already noted. It is in this work that the opinions of Fracastoro, announced more than a century earlier, are at last accorded recognition. Among the curiosities of palaeontological literature belonging to this period should be mentioned Buonamici's dissertation on *Glossopetrae*,[4] published in 1668.

Seventeenth and Eighteenth Centuries. The important contributions to palaeontology made by Fabius Colonna, Nicolas Steno, and Augustin Scilla during the seventeenth century are well known, hence we

[1] Ambrosini, Musaeum metallicum. 1648.

[2] Mercato, M., Metallotheca [Vaticana], opus posthumum. Rome, 1717.

[3] Olivi, G. B., De recondites et praecipius collectaneis a Francesco Calceolario Veronensis, in Museo adservatis. Verona, 1584; and Venice, 1593.

[4] Buonamici, F., Sulle glossopetre, gli occhi di serpe ed altre pietre, etc. (Opusc. Sicil. Vol. XII.), 1668. References to other essays of this period on the same subject will be found in Palaeontographica, XLI. pp. 149–153, 1895.

may pass over these authors with the bare mention of their names.[1] Throughout this period the growth of museums continued apace, and attempts to describe their fossil contents succeeded better as Fracastoro's ideas were revived and gradually gained acceptance. Descriptions appeared of the Aldrovandi collection in 1648, as has been stated, and in 1656 of Count Moscardo's[2] museum in Verona, both of which contained interesting fish remains. Another museum famous for its fossils was that of Zannichelli[3] of Venice, who prepared an elaborate catalogue of its contents, published first in 1720, with additions in 1736. Attention should also be called to the important essay by Vallisneri[4] "*On Marine Bodies found in the Mountains*," published in 1721, in which reference is made to the fishes and crustaceans occurring at Monte Bolca. Appended to the complete works of this author is a letter on Bolca fishes, with a map of the locality, by Ferdinand Marsili.[5]

As remarked by Lyell, the writings of Vallisneri are rich in geological observations. He attempted the first general sketch of the marine deposits of Italy, their geographical extent and most characteristic organic remains, and was the principal opponent amongst his countrymen of Woodward's diluvian hypothesis. In 1702 the fossil fishes of Monte Bolca were made the subject of a communication before the French Academy by Maraldi,[6] an Italian astronomer, and the same body was similarly addressed by J. J. Scheuchzer, whose "*Piscium querelae et vindiciae*" and other writings provoked wide-spread discussion. Notices of vertebrate remains appear also in the dissertations of Spada,[7]

[1] On these writers one may consult the following: Seguenza, G., Agostino Scilla. Messina, 1868. — Marsh, O. C., History and Methods of Palaeontological Discovery (Proc. Amer. Assoc. Adv. Sci. 1879), 1880. — Ward, L. F., Sketch of Palaeobotany, Fifth Ann. Rept. U. S. Geol. Surv. (1883-1884), 1885. — Zittel, K. A., Geschichte der Geologie und Paläontologie. Munich, 1899.

[2] Note overo memorie del Museo di Lodovico Moscardo, dal medesimo descritte. Padua, 1656. Some poor figures of Bolca fishes are given on p. 182.

[3] Zannichelli, Apparatus rariorum Musaei Zannicchelli. Venice, 1720. *Idem*, Enumeratio rerum naturalium Musaei Zannichelli. Venice, 1736. This catalogue contains the earliest mention of fossil hippopotami in Italy.

[4] Vallisneri, A., De' corpi marini che su' monti si trovano. Venice, 1721.

[5] Vallisneri, A., Opere, II. p. 359.

[6] Maraldi, J. P., Diverses observations de physique générale, § xi. (Hist. Acad. Roy. Sci., année 1703). Paris, 1720. This is the earliest communication on Bolca fishes published by any learned society. The earliest in English is a paper by G. Graydon, entitled "On the fish enclosed in stone of Monte Bolca," which appears in the transactions of the Royal Irish Academy for 1794 (Vol. V., p. 281).

[7] Spada, J. J., Dissertazione ove si prova che i corpi marini petrificati non sono

a learned priest of Grezzana, who wrote in 1737, and again in 1744, to prove that the fossils found near Verona were not of diluvian origin. Scipio Maffei[1] was another active collector and writer on Bolca fishes during the middle of the eighteenth century. But we cannot dwell upon any of the numerous minor publications of this time, nor even upon the more important contributions of Moro,[2] Generelli,[3] and others. With this brief sketch we must conclude our survey of pre-Linnaean literature, and pass on to the modern era; for from the time of the two great Swedish naturalists onward, Linné and Artedi, the latter of whom is justly styled the "father of ichthyology," a new order of things existed.

One of the earliest writers of the new era in natural science, and indeed the first who attempted a specific determination of the Bolca fishes, was Cammillo Zampieri d'Imola,[4] whose Catalogue of the Ginanni Museum, published in 1762, is decidedly meritorious. His identification of species, however, based as it was upon the treatises of Willoughby and Ray, was altogether faulty. The celebrated Fortis also made unsuccessful endeavors to identify Bolca fishes with the species described by Bloch and Broussonet. Fortis had already noted the occurrence of fossil fishes[5] in other parts of the Alpine strata, but on turning his attention to the Bolca forms, he encountered difficulties.[6] He was mis-

diluviani. Verona, 1737. — *Idem*, Corporum lapidefactorum agri veronensis catalogus. Verona, 1744. In Plate ii. of this work is given a tolerable figure of *Semiophorus*. See also Cobres's estimate of Spada, in Büchersammlung der Naturgeschichte, I. p. 20.

[1] Maffei, F. S., Del Monte Bolca, della sua Pesciaia, e degli annessi Monti Calonnari, etc., in his *Compendio della Verona Illustrata*, Vol. I., pp. 217–230, pl. i.–viii. Verona, 1795.

[2] Moro, L., Sui crostacei ed altri corpi marini che si trovano sui monti. 1740. The same work was also published in German under the title of "Neue Untersuchungen über die Abänderungen der Erde." Leipzic, 1751.

Moro's ideas were appropriated without acknowledgment by Edward King in a paper read before the Royal Society entitled "An attempt to account for the Universal Deluge" (Phil. Trans., LVII. pp. 44–57), 1767. For a biographical sketch of Lazzaro Moro see Giornale di Storia naturale del Griselini, I. p. 79.

[3] Generelli, C., Dei crostacei e di altre produzione del mare. 1749.

[4] Zampieri, C., Produzione naturali che si ritrovano nel Museo Ginanni in Ravenna. Lucca, 1762.

[5] Fortis, A., Viaggi in Dalmazia, II. p. 239. 1774.

[6] Fortis, A., Extrait d'une lettre, etc. Journ. de Phys., XXVIII. 1786. In a later communication to the same journal, Fortis vigorously disclaims authorship of the catalogue of Bolca fishes which is appended to his first article. In this anonymous postscript an extravagant valuation (28,000 liv.) is placed upon the Bozza Collection, which then consisted of about six hundred specimens.

led into supposing certain species to be identical with modern tropical forms, and his somewhat fanciful theories to explain their occurrence in northern Italy plunged him into a spirited controversy with another prominent naturalist, Domenica Testa. Their letters, written in a style that is both elegant and incisive, show wide erudition and good argumentative ability on both sides. The correspondence was finally collected and published in book form, with comments of his own, by Count Giambattista Gazola [1] of Verona, in 1793 and 1794.

By this time a very lively interest had arisen in regard to the fishes of Monte Bolca, and the Veronese collections became greatly augmented as the result of excavations that had been undertaken on purpose to secure them. The culmination of this activity was marked by the appearance in 1796 of an elaborate work by G. Serafino Volta, entitled *Ittiolitologia Veronese*. In the compilation of this famous monograph, which was illustrated by nearly fourscore excellent plates, Volta was aided by several collaborators, chief amongst whom was Count Gazola himself. Volta had already published in 1789 a list of the fossil fishes occurring at Monte Bolca,[2] in which about one hundred species were enumerated, and of these twenty-five were erroneously identified with recent forms. The determinations in his final memoir were scarcely more fortunate, Agassiz having afterwards declared that there was only one [3] adequately established species in the whole work, that one being *Blochius longirostris*. The practical value of Volta's work, however, was immeasurably increased by the redetermination of his originals, an authentic list of the figured specimens being published by Agassiz [4] in 1833. In this list Volta's originals are regarded as belonging to 90 species and 69 genera, all of the species being marine, and none of them represented in the existing fauna.

[1] Gazola, G., Lettere recentemente pubblicate sui pesci fossili veronesi, con annotazioni inediti agli estratti delle medesime. Milan, 1793, and Verona, 1794.

[2] Volta, G. S., Degl' impietrimenti del Territorio Veronese, etc. Lettera al Sig. Vincenzo Bozza, 1789. *Idem*, Prospetto del Museo Bellisomi. 1787.

[3] This is not strictly true. The names of over a dozen species described by Volta as new are rejected by Agassiz, and others substituted, for the reason that the forms were regarded in the first instance as belonging to existing genera. A list of the species which should properly be credited to Volta is as follows:

Blochius longirostris, Eocottus veronensis, Ephippus asper, Ductor vestenae, Mene rhombeus, Monopterus gigas, Platax papilio, Pygaeus bolcanus, Pycnodus apodus, Rhamphosus rastrum, Rhinellus lesiniformis, Semiophorus velifer, Vomeropsis triurus, Xiphopterus falcatus.

[4] Agassiz, L., Revue critique des Poissons Fossiles figurés dans l'Ittiolitologia Veronese. Neuchâtel, 1833. Also in German in the Neues Jahrbuch for 1835.

Volta narrates in considerable detail the history of the principal collections which furnished him with material. Of these there were ten belonging to Veronese gentlemen, the most notable one being the property of Count Gazola, with which the Bozza and Dionisi collections became shortly afterwards united. The circumstances which deprived Count Gazola of most of his specimens in 1797, their removal to Paris by order of First Consul Bonaparte, and their presentation by him to the Museum of Natural History in that city are familiar historical facts.

The second largest suite of fossil fishes was that belonging to the Marchese Ottavio di Canossa, which afterwards became enlarged by the purchase of Julius Cæsar Moreni's collection. Agassiz never had access to the Canossa Collection, nor in fact to any in Italy, but portions of it were described by subsequent authors at various times. The collection remained intact at Verona until 1903, when it passed into the possession of natural history dealers and museums of several countries. Heckel's figured specimen of *Palaeobalistum orbiculatum*, for instance, was acquired by the British Museum, Massalongo's types of *Archiophis* were divided between the Harvard and Berlin Museums, and the Carnegie Museum at Pittsburg also obtained several of Massalongo's figured specimens.

Count Gazola's first care on suffering the loss of his splendid collection was to undertake the formation of a new one. Excavations at Bolca were recommenced, and on the death of Count Ronconi a number of fine specimens which he had brought together passed into Gazola's hands; the result of all this activity being that, phoenix-like, his museum became speedily rehabilitated. This second collection of Count Gazola is preserved in the Museo Civico of Verona, but is not now, and unfortunately never has been, fully accessible for study. The scientific value of this collection was fully appreciated by Jacob Heckel, who first visited it in 1850. The condition in which he found the museums of Verona, Padua, Venice, and other cities at that time is set forth by him in a highly entertaining narrative which he communicated to the Vienna Academy,[1] under whose patronage the journey was undertaken. In referring to the Gazola Collection, he laments particularly the fact that it never came under Agassiz's observation, for this "heerliches Material," as he calls it, would have helped him to a much more complete understanding of many interesting species, and even genera, and would have enriched our knowledge of the Bolca fauna with valuable details.

[1] Heckel, J., Bericht über eine Reise, etc. (Sitzungsber Akad. Wissensch. Wien, VII. p. 318), 1851.

Heckel also remarks that the same collection "ist bei weitem reicher als jene des Marchese Canossa und liefert eine beinahe vollständige Uebersicht sämmtlicher organischer Reste, welche in den tertiären Ablagerungen des Monte Bolca enthalten sind."

The only other private collection which we need notice here is that brought together early in the nineteenth century by Luigi Castellini, of Castelgomberto, which now forms one of the principal treasures of the Padua Museum. This comprised in all about five hundred fishes from Monte Bolca and Monte Postale, some of which were remarkable for their large size and excellent preservation, as well as for their rarity. "Sie ist auf drei grossen Doppelpulten aufgestellt," writes Heckel in his naïve narrative of 1850, "und enthält ausser vielen der seltenen Arten und manchen Prachtstücke, sämmtliche in Doppelplatten, auch einige bisher unbeschriebene Species, deren nähere Bekanntschaft mich um so angenehmer berührte, da ich bereits mehrere derselben zu Verona in der schönen Sammlung des Herrn Grafen Gazola unter Glas bemerkt hatte." Some of these new forms were shortly afterwards described by Heckel, and others have been investigated by more recent writers.

We return now to the first Gazola Collection, which, as we have seen, was transported to Paris in 1797, and deposited in the Museum of Natural History. It is well known that Cuvier spent considerable time in the investigation of this material, with the intention of preparing a monograph upon it, — a task, however, which was ceded finally to Agassiz. Some use of the collection was made by de Blainville in the preparation of his article [1] on fossil fishes, published in 1818, but it cannot be said that our knowledge was materially increased by this author. It remained for the elder Agassiz, in 1831 and 1832, to ascertain the true nature of the extinct forms of fish life here represented, and by means of this and other collections which he studied, to give the first accurate and best general account we possess of the remarkable ichthyic fauna occurring at Monte Bolca.

Agassiz's own estimate of the value of the Gazola Collection is thus expressed by him: "Le Muséum d'Histoire Naturelle de Paris a été pour moi l'une des mines les plus riches que j'aie exploitée. . . . La collection de poissons fossiles la plus importante qui existe maintenant, et en même temps qui offre le plus d'intérêt historique, est, sans contredit, celle du comte de Gazola, qui a fourni les originaux pour l'*Ittiolitologia Veronese*. . . . Je l'ai entièrement revue et complète-

[1] De Blainville, H. D., Sur les Ichthyolites, ou les Poissons Fossiles, in his Nouveau Dictionnaire d'Histoire Naturelle, Vol. XXVIII. Paris, 1818.

ment décrite vers la fin de 1831 et pendant les huit premiers mois de l'année 1832, et j'ai inscrit mes déterminations sur le revers de toutes les plaques."[1]

The total number of species recognized by Agassiz as the result of his investigations of the Gazola Collection and other Bolca material that came under his observation was 127, and the total number of genera 77. Many of Volta's types were refigured by him, but in several cases descriptions were given without fresh illustration, and in others Volta's figures were merely renamed without further description. Some confusion in the nomenclature was occasioned by reason of other names being applied to species which had been duly established both by Volta and by de Blainville, and in about a dozen instances MS. names were proposed for certain forms which up to the present time have remained undescribed. These *types inédits*, designated as such in Agassiz's handwriting, have recently been investigated by the present writer, and their publication undertaken by the French Geological Society. It must not be supposed, however, that all of Volta's types which originally formed part of the Gazola Collection are now preserved in the Paris Museum, nor was it possible even in Agassiz's time to account for the specimens which were then missing.[2] Owing to the historic and scientific interest attaching to these originals, it is to be hoped that all such as are still in existence and have escaped notice amongst other collections may again come to light. Lists are given below of all the types and hypotypes belonging to the Gazola Collection in Paris.

It will be sufficient to pass over the post-Agassizian literature of the Bolca fish-fauna very briefly, merely indicating the names of the principal contributors. These are, in chronological order, Jacob Heckel, Rudolf Kner, Franz Steindachner, Raffaele Molin, Abramo Massalongo, Paolo Lioy, Achille de Zigno, Francesco Bassani, Wladislaw Szajnocha,

[1] Agassiz, L., Poissons Fossiles, I. p. 5. Neuchâtel, 1833.

[2] The Library of the Museum of Comparative Zoölogy possesses the identical copy of Volta's work employed by Professor Agassiz in his determinations of the types in the Gazola Collection at Paris. Each figure of the plates is marked with Agassiz's revised designation, and in cases where the originals were wanting, the fact is so indicated. His private copy of de Blainville's *Poissons Fossiles*, in the same library, likewise contains valuable corrections and annotations. The Museum has received through Prof. R. T. Jackson, who obtained it from Prof. J. E. Wolff, a specimen which formerly belonged to the Gazola Collection at Paris, but which disappeared from it probably during some of the early vicissitudes through which the collection passed. Several interesting notices of the latter are to be found in the papers of Faujas-St.-Fond, de Jussieu, Cuvier, and others, published in the early volumes of the *Annales* and of the *Mémoires du Museum d'Histoire Naturelle.*

Carl Gorganovic-Kramberger, Otto Jaekel, and A. Smith Woodward. Some seventy-five additional species have been described by these authors in the aggregate, making a total representation of slightly more than two hundred. A rather considerable number of these, however, are undoubtedly synonyms, and the status of a score or more of imperfectly defined species requires further investigation.

The best general account of the geology of the region in which this fish-fauna occurs is contained in an inaugural dissertation by the late Munier-Chalmas, entitled "*Étude du Tithonique, du Crétacé et du Tertiaire du Vicentin*" (Paris, 1891), the usefulness of which is increased by a copious bibliography. Mention should also be made of Enrico Nicolis' "*Carta Geologica della Provincia di Verona*" (Verona, 1882), and of his "*Sugli antici Corsi dell' Adige*" (Rome, 1898). The invertebrate fauna of Monte Bolca forms the subject of special memoirs by Cattullo [1] and Oppenheim.[2]

List of Specimens in the Gazola Collection of the Paris Museum Figured in Volta's "Ittiolitologia Veronese," Arranged in Serial Order.

Volta (*Itt. Ver.*).		Refigured by Agassiz (*Poissons Fossiles*).
Pl. 3, Fig. 1.	*Carcharias* (*Scoliodon*) *cuvieri* (Ag.).	
4.	*Platax pinnatiformis* (Blv.).	Vol. IV. Pl. 41.
5, " 1.	*Aulostoma bolcense* (Blv.).	Vol. IV. Pl. 35, Fig. 3.
5, " 2.	*Fistularia longirostris* (Blv.).	Vol. IV. Pl. 35, Fig. 4.
5, " 3.	*Calamostoma breviculum* (Blv.).	Vol. II. Pl. 74, Fig. 1.
5, " 4.	*Rhamphosus rastrum* (Volta).	Vol. IV. Pl. 32, Fig. 7.
7, " 1.	*Semiophorus velifer* (Volta).	Vol. IV. Pl. 37 *a*, Fig. 2.
7, " 2.	" " "	Vol. IV. Pl. 37 *a*, Fig. 1.
7, " 3.	" *velicans* (Blv.).	Vol. IV. Pl. 37.
8, " 1.	*Pomacanthus subarcuatus* (Blv.).	Vol. IV. Pl. 19, Fig. 2.
9, Figs. 1, 2.	*Trygon muricatus* (Volta).	
10, Fig. 1.	*Ephippus rhombus* (Blv.).	
11, " 1.	*Eocottus veronensis* (Volta).	Vol. IV. Pl. 34, Fig. 3.
11, " 2.	" " "	Vol. IV. Pl. 34, Fig. 4.
12, " 1.	*Blochius longirostris* Volta.	Vol. II. Pl. 44, Fig. 3.
12. " 2.	" " "	

[1] Cattullo, T. A., Memorie sopra li corpi organizzati fossili del Bolca, etc. (Giornale di Pavia), 1818–22.

[2] Oppenheim, P., Die Eocänfauna des Monte Postale bei Bolca in Veronesischen (Palaeontographica, XLIII. pp. 125–222), 1896.

Volta (*Itt. Ver.*).		Refigured by Agassiz (*Poissons Fossiles*).
Pl. 13, Fig. 1.	*Sparnodus vulgaris* (Blv.).	Vol. IV. Pl. 29, Fig. 2.
13, " 2.	*Spinacanthus cuneiformis* (Blv.).	Vol. V. Pl. 39, Fig. 1.
14, " 1.	*Enoplosus pygopterus* Ag.	Vol. IV. Pl. 9, Fig. 1.
17, " 1.	*Sparnodus vulgaris* (Blv.).	Vol. IV. Pl. 29, Fig. 2.
17, " 3.	*Lates gracilis* Ag.	Vol. IV. Pl. 3, Fig. 2.
19.	*Acanthonemus subaureus* (Blv.).	Vol. V. Pl. 4.
20, " 1.	*Ephippus asper* (Volta).	
20, " 2.	*Pristigenys substriatus* (Blv.).	
22, " 1.	*Naseus nuchalis* Ag.	Vol. IV. Pl. 36, Fig. 2.
23, " 1.	*Ophisurus acuticaudus* Ag.	
23, " 3.	*Anguilla leptoptera* Ag.	
24, " 3.	*Rhamphognathus sphyraenoides* (Ag.).	Vol. V. Pl. 38, Fig. 2.
25, " 1.	*Chanoides macropoma* (Ag.).	
25, " 2.	" " "	Vol. V. Pl. 37 *b*, Fig. 4.
26, " 1.	*Platax papilio* (Volta).	Vol. IV. Pl. 42.
26, " 2.	*Zanclus brevirostris* Ag.	Vol. IV. Pl. 38, Figs. 1, 2.
27.	*Thynnus* (*?*) *bolcensis* Ag.	
29, " 1.	" *lanceolatus* (Ag.).	
29, " 4.	*Urosphen dubia* (Blv.).	
30.	*Callipteryx recticaudus* Ag.	Vol. IV. Pl. 33, Fig. 2.
31, " 1.	*Sparnodus elongatus* Ag.	Vol. IV. Pl. 28, Fig. 1.
31, " 2.	*Acanthurus tenuis* Ag.	Vol. IV. Pl. 36, Fig. 1.
32, " 1.	*Sparnodus elongatus* Ag.	Vol. IV. Pl. 23 *b*, *infra*.
32, " 2.	*Ductor vestenae* (Volta).	Vol. V. Pl. 12.
33.	*Naseus rectifrons* Ag.	Vol. IV. Pl. 36, Fig. 3.
35, " 1.	*Pycnodus apodus* (Volta).	
35, " 3.	*Vomeropsis triurus* (Volta).	Vol. V. Pl. 5.
35, " 4.	*Cyclopoma* (*?*) *micracanthum* (Ag.).	
37.	*Labrus valenciennesi* Ag.	Vol. V. Pl. 39, Fig. 2.
38, " 1.	*Paranguilla tigrina* (Ag.).	Vol. V. Pl. 49.
39, " 3.	*Trachynotus tenuiceps* Ag.	Vol. V. Pl. 7, Figs. 1, 2.
39, " 5.	*Engraulis evolans* (Ag.).	Vol. V. Pl. 37 *b*, Figs. 1, 2.
40.	*Palaeobalistum orbiculatum* (Blv.).	
42, " 1.	*Ostracion dubius* (Blv.).	Vol. II. Pl. 74, Figs. 4, 5.
42, " 2.	"*Pegasus volans*" Linn. (indeterminable).	
42, " 3.	*Lophius brachysomus* Ag.	Vol. V. Pl. 40, Figs. 1, 2.
44, " 1.	*Amphistium paradoxum* Ag.	
44, " 2.	*Vomeropsis triurus* (Volta).	Vol. V. Pl. 6.
45, " 1.	*Toxotes antiquus* Ag.	Vol. IV. Pl. 43.
45, " 2.	*Dules temnopterus* Ag.	Vol. IV. Pl. 21, Figs. 1, 2.
45, " 3.	*Sparnodus microstomus* (Ag.).	
47.	*Monopterus gigas* Volta.	
48, " 3.	*Atherina macrocephala* Ag.	

Volta (*Itt. Ver.*).			Refigured by Agassiz (*Poissons Fossiles*).
Pl. 51, Fig.	2.	*Holocentrum macrocephalum* Blv.	Vol. IV. Pl. 14.
51, "	3.	*Acanthonemus subaureus* (Blv.).	Vol. V. Pl. 3.
53, "	2.	*Leptocephalus medius* Ag.	
54.		*Dentex leptacanthus* Ag.	Vol. IV. Pl. 26.
55, "	1.	*Blochius longirostris* Volta. (The head of an anguilliform fish has been substituted for the one properly belonging to this specimen.)	
55, "	2.	*Orycynus latior* Ag.	Vol. V. Pl. 24.
56, "	2.	*Apogon spinosus* Ag.	Vol. IV. Pl. 9, Figs. 2, 3.
56, "	3.	*Cyclopoma (?) micracanthum* (Ag.).	
57.		*Xiphopterus falcatus* (Volta).	
58, "	1.	*Pseudosyngnathus opisthopterus* (Ag.).	
58, "	2.	*Ductor vestenae* (Volta).	
59.		*Pygaeus bolcanus* (Volta).	Vol. IV. Pl. 20.
60, "	2.	*Sparnodus vulgaris* (Blv.).	Vol. IV. Pl. 28, Fig. 3.
61.		*Platyrhina gigantea* (Blv.).	
62.		*Sphyraena bolcense* Ag.	
69, "	1.	*Seriola analis* Ag.	
70.		*Blochius longirostris* Volta.	
72, "	1.	*Holocentrum macrocephalum* Blv.	
72, "	4.	*Myripristis homopterygius* Ag.	
73.		*Sparnodus vulgaris* (Blv.).	
74.		*Cyclopoma gigas* Ag.	
75, "	1.	*Rhamphosus rastrum* (Volta).	
76.		*Cyclopoma spinosum* Ag.	

Alphabetical List of the Type and Figured Specimens of Bolca Fishes Belonging to the Gazola Collection, now preserved in the Paris Museum of Natural History.

1.	*Acanthonemus subaureus* (Blv.).	Volta, Pl. 51, Fig. 3; Ag., V. Pl. 3.
2.	" " "	Volta, Pl. 19; Ag., V. Pl. 4.
3.	*Acanthurus tenuis* Ag.	Volta, Pl. 31, Fig. 2; Ag., IV. Pl. 36, Fig. 1.
4.	*Amphistium paradoxum* Ag.	Volta, Pl. 44, Fig. 1.
5.	" "	Ag., V. Pl. 13.
6.	*Anguilla branchiostegalis* Ag. (MS.).	
7.	" *brevicula* Ag.	Ag., V. Pl. 43, Fig. 1.
8.	" *leptoptera* Ag.	Volta, Pl. 23, Fig. 3.
9.	*Apogon spinosus* Ag.	Volta, Pl. 56, Fig. 2; Ag., IV. Pl. 9, Figs, 2, 3.
10.	*Atherina macrocephala* Ag.	Volta, Pl. 48, Fig. 3.

11.	*Aulostoma bolcense* (Blv.).	Volta, Pl. 5, Fig. 1; Ag., IV. Pl. 35, Fig. 3.
12.	" " "	Ag., IV. Pl. 35, Fig. 2.
13.	*Blochius longirostris* Volta.	Volta, Pl. 12, Fig. 1; Ag., II. Pl. 44, Fig. 3.
14.	" " "	Volta, Pl. 12, Fig. 2.
15.	" " "	Volta, Pl. 55, Fig. 1.
16.	" " "	Volta, Pl. 70.
17.	*Calamostoma breviculum* (Blv.).	Volta, Pl. 5, Fig. 3; Ag., II. Pl. 74, Fig. 1.
18.	*Callipteryx recticaudus* Ag.	Volta, Pl. 30; Ag., IV. Pl. 33, Fig. 2.
19.	" *speciosus* Ag.	Ag., IV. Pl. 33, Fig. 1.
20.	*Carangopsis dorsalis* Ag.	Ag., V. Pl. 8.
21.	*Carcharius* (*Scoliodon*) *cuvieri* (Ag.).	Volta, Pl. 3, Fig. 1.
22.	*Chanoides leptostea* Ag. (MS.).	
23.	" *macropoma* (Ag.).	Volta, Pl. 25, Fig. 1.
24.	" " "	Volta, Pl. 25, Fig. 2; Ag., V. Pl. 37 *b*, Fig. 4.
25.	*Coelogaster analis* Ag. (MS.).	
26.	*Cybium speciosum* Ag.	Ag., V. Pl. 25.
27.	*Cyclopoma gigas* Ag.	Ag., IV. Pl. 2.
28.	" " "	Volta, Pl. 74.
29.	" (?) *micracanthum* (Ag.).	Volta, Pl. 35, Fig. 4.
30.	" *spinosum* Ag.	Volta, Pl. 76.
31.	" " "	Ag., IV. Pl. 1.
32.	*Dentex crassispinus* Ag.	
33.	" *leptacanthus* Ag.	Volta, Pl. 54; Ag., IV. Pl. 26.
34.	*Ductor vestenae* (Volta).	Volta, Pl. 32, Fig. 2; Ag., V. Pl. 12.
35.	" " "	Volta, Pl. 58, Fig. 2.
36.	*Dules temnopterus* Ag.	Volta, Pl. 45, Fig. 2; Ag., IV. Pl. 21, Figs. 1, 2.
37.	*Engraulis evolans* Ag.	Volta, Pl. 39, Fig. 5; Ag., V. Pl. 37 *b*, Figs. 1, 2.
38.	*Enoplosus pygopterus* Ag.	Volta, Pl. 14, Fig. 1; Ag., IV. Pl. 9, Fig. 1.
39.	*Eomyrus formosissimus* (Ag.) (MS.).	
40.	" *interspinalis* " "	
41.	" *latispinus* (Ag.).	Ag., V. Pl. 43, Fig. 4.
42.	*Eocottus veronensis* (Volta).	Volta, Pl. 11, Fig. 1; Ag., IV. Pl. 34, Fig. 3.
43.	" " "	Volta, Pl. 11, Fig. 2; Ag., IV. Pl. 34, Fig. 4.
44.	*Ephippus asper* (Volta).	Volta, Pl. 20, Fig. 1.
45.	" " "	Ag., IV. Pl. 39, Fig. 3.
46.	" *rhombus* (Blv.).	Volta, Pl. 10, Fig. 1.

47.	*Ephippus rhombus* (Blv.).	Ag., IV. Pl. 40.
48.	*Fistularia longirostris* (Blv.).	Volta, Pl. 5, Fig. 2; Ag., IV. Pl. 35, Fig. 4.
49.	*Holocentrum macrocephalum* Blv.	Volta, Pl. 51, Fig. 2; Ag., IV. Pl. 14.
50.	" " "	Volta, Pl. 72, Fig. 1.
51.	" *pygmaeum* Ag.	Ag., IV. Pl. 15, Fig. 1.
52.	*Holosteus esocinus* Ag.	Ag., V. Pl. 43, Fig. 5.
53.	*Labrax schizurus* Ag.	Ag., IV. Pl. 13, Fig. 3.
54.	*Labrus valenciennesi* Ag.	Volta, Pl. 37; Ag., V. Pl. 39, Fig. 2.
55.	*Lates gracilis* Ag.	Volta, Pl. 17, Fig. 3; Ag., IV. Pl. 3, Fig. 2.
56.	" " "	Ag., IV. Pl. 5.
57.	*Leptocephalus medius* Ag.	Volta, Pl. 53, Fig. 2.
58.	*Lophius brachysomus* Ag.	Volta, Pl. 42, Fig. 3; Ag., V. Pl. 40, Figs. 1, 2.
59.	" " "	Ag., V. Pl. 40, Figs. 3, 4.
60.	*Mene oblongus* (Ag.).	Ag., V. Pl. 1, Figs. 1, 2.
61.	*Monopterus gigas* Volta.	Volta, Pl. 47.
62.	*Myripristis homopterygius* Ag.	Volta, Pl. 72, Fig. 4.
63.	*Naseus nuchalis* Ag.	Volta, Pl. 22, Fig. 1; Ag., IV. Pl. 36, Fig. 2.
64.	" *rectifrons* Ag.	Volta, Pl. 33; Ag., IV. Pl. 36, Fig. 3.
65.	*Odonteus sparoides* Ag.	Ag., IV. Pl. 39, Fig. 2.
66.	*Ophisurus acuticaudus* Ag.	Ag., V. Pl. 23, Fig. 1.
67.	*Orycynus latior* Ag.	Volta, Pl. 55, Fig. 2; Ag., V. Pl. 24.
68.	*Ostracion dubius* (Blv.).	Volta, Pl. 42, Fig. 1; Ag., II. Pl. 74, Figs. 4, 5.
69.	*Pagellus microdon* Ag.	Ag., IV. Pl. 27, Fig. 1.
70.	*Palaeobalistum orbiculatum* (Blv.).	Volta, Pl. 40.
71.	*Paranguilla tigrina* (Ag.).[1]	Volta, Pl. 38, Fig. 1; Ag., V. Pl. 49.
72.	"*Pegasus volans*" Linn.	Volta, Pl. 42, Fig. 2.
73.	*Pelates quindecimalis* Ag.	Ag., IV. Pl. 22.
74.	*Platax papilio* (Volta).	Volta, Pl. 26, Fig. 1; Ag., IV. Pl. 42.
75.	" *pinnatiformis* (Blv.).	Volta, Pl. 4; Ag., IV. Pl. 41.
76.	" *subvespertilio* (Blv.).	Volta, Pl. 6.
77.	" " "	Ag., IV. Pl. 41 *a*.
78.	*Platinx intermedius* Eastm.	*(In press.)*
79.	" *macropterus* (Blv.).	Ag., V. Pl. 14.
80.	*Platyrhina gigantea* (Blv.).	Volta, Pl. 61.
81.	*Pomacanthus subarcuatus* (Blv.).	Volta, Pl. 8, Fig. 1; Ag., IV. Pl. 19, Fig. 2.
82.	*Pristigenys substriatus* (Blv.).	Volta, Pl. 20, Fig. 2.
83.	*Pristipoma furcatum* (Ag.).	Ag., IV. Pl. 39, Fig. 1.
84.	*Pseudosyngnathus opisthopterus* (Ag.).	Volta, Pl. 58, Fig. 1.

[1] The relations of this type are discussed by Cuvier in Mém. Mus. d'Hist. Nat., Vol. I. (1815), p. 321.

85.	*Pterygocephalus paradoxus* Ag.	Ag., IV. Pl. 32, Figs. 5, 6.
86.	*Pycnodus apodus* (Volta).	Volta, Pl. 35, Fig. 1.
87.	*Pygaeus bolcanus* (Volta).	Volta, Pl. 59 ; Ag., IV. Pl. 20.
88.	*Rhamphosus rastrum* (Volta).	Volta, Pl. 5, Fig. 4 ; Ag., IV. Pl. 32, Fig. 7.
89.	" " "	Volta, Pl. 75, Fig. 1.
90.	*Rhamphognathus paralepoides* Ag.	Ag., V. Pl. 38, Fig. 1.
91.	" *sphyraenoides* (Ag.).	Volta, Pl. 24, Fig. 3 ; Ag., V. Pl. 38, Fig. 2.
92.	*Scatiphagus frontalis* Ag.	Ag., IV. Pl. 39, Fig. 4.
93.	*Semiophorus velicans* (Blv.).	Volta, Pl. 7, Fig. 3; Ag., IV. Pl. 37.
94.	" *velifer* (Volta).	Volta, Pl. 7, Fig. 1 ; Ag., IV. Pl. 37 *a*, Fig. 2.
95.	" " "	Volta, Pl. 7, Fig. 2 ; Ag., IV. Pl. 37 *a*, Fig. 1.
96.	*Seriola analis* (Ag.).	Volta, Pl. 69, Fig. 1.
97.	" *prisca* (Ag.).	Ag., V. Pl. 11 *a*.
98.	*Serranus rugosus* Heckel.	Ag., IV. Pl. 23 *b* (*supra*).
99.	*Sparnodus elongatus* Ag.	Volta, Pl. 32, Fig. 1 ; Ag., IV. Pl. 23 *b* (*infra*).
100.	" " "	Volta, Pl. 31, Fig. 1 ; Ag., IV. Pl. 28, Fig. 1.
101.	" *microstomus* (Ag.).	Volta, Pl. 45, Fig. 3.
102.	" " "	Ag., IV. Pl. 23, Figs. 1, 2.
103.	*Sparnodus vulgaris* (Blv.).	Volta, Pl. 13, Fig. 1, and Pl. 17, Fig. 1 ; Ag., IV. Pl. 29, Fig. 2.
104.	" " "	Volta, Pl. 60, Fig. 2 ; Ag., IV. Pl. 28, Fig. 3.
105.	" " "	Volta, Pl. 73.
106.	" " "	Ag., IV. Pl. 29, Fig. 1.
107.	" " "	Ag., IV. Pl. 29, Fig. 3.
108.	*Sphyraena bolcensis* Ag.	Volta, Pl. 62.
109.	*Spinacanthus cuneiformis* (Blv.).	Volta, Pl. 13, Fig. 2; Ag., V. Pl. 39, Fig. 1.
110.	*Thynnus* (*?*) *bolcensis* Ag.	Volta, Pl. 27.
111.	" *lanceolatus* (Ag.).	Volta, Pl. 29, Fig. 1.
112.	" " "	Ag., V. Pl. 23.
113.	" (*?*) *propterygius* Ag.	Ag., V. Pl. 27.
114.	*Toxotes antiquus* Ag.	Volta, Pl. 45, Fig. 1; Ag., IV. Pl. 43.
115.	*Trachynotus tenuiceps* Ag.	Volta, Pl. 39, Fig. 3; Ag., V. Pl. 7, Figs. 1, 2.
116.	*Trygon muricatus* (Volta).	Volta, Pl. 9, Fig. 1.
117.	" " "	Volta, Pl. 9, Fig. 2.
118.	*Urolophus crassicaudatus* (Blv.).	Type not figured (*de est ?*).
119.	*Urosphen dubia* (Blv.).	Volta, Pl. 29, Fig. 4.

120. *Urosphen dubia* (Blv.). Ag., IV. Pl. 35, Fig. 6.
121. *Vomeropsis triurus* (Volta). Volta, Pl. 44, Fig. 2; Ag., V. Pl. 6.
122. " " " Volta, Pl. 35, Fig. 3; Ag., V. Pl. 5.
123. *Xiphopterus falcatus* (Volta). Volta, Pl. 57.
124. *Zanclus brevirostris* Ag. Volta, Pl. 26, Fig. 2; Ag., IV. Pl. 38, Figs. 1, 2.

II. SYSTEMATIC DESCRIPTIONS.

ELASMOBRANCHII.

RAJIDAE.

Platyrhina gigantea (Blv.).

1796. *Raja torpedo* G. S. Volta, Ittiolit. Veronese, p. 521, Plate LXI.
1818. *Narcobatus giganteus* H. D. de Blainville, Nouv. Dict. d'Hist. Nat., xxvii. p. 337.
1835. *Torpedo gigantea* L. Agassiz, Neues Jahrb., p. 297 (name only).
1843. *Torpedo gigantea* L. Agassiz, Poiss. Foss., iii. p. 382; ** iv. p. 38 (name only).
1860. *Narcine gigantea* R. Molin, Sitzungsber. Akad. Wiss. Wien, xl. p. 585.
1874. *Torpedo gigantea* A. de Zigno, Catalogo ragionato dei Pesci Fossili, p. 177.
1894. *Platyrhina gigantea* O. Jaekel, Die eocänen Selachier vom Monte Bolca, p. 108, text-fig. 19.

The holotype of this species is preserved in the Paris Museum of Natural History, and not, as stated by Baron de Zigno, in the second Gazola Collection at Verona. In its present state the disk is remarkable for its great antero-posterior elongation. De Blainville was of the opinion that this was not a character properly belonging to the specimen, but one due to deceptive appearances, a portion of the disk having become folded upon itself. O. Jaekel, without having had access to the specimen, imagined that the disk had become deformed by mechanical agencies subsequent to the death of the creature. An examination of the original leads the present writer to conclude that there is no evidence of a folding over of the edges of the disk, nor of distortion due to pressure or other causes. Although extremely probable that the lateral margin of the disk escaped fossilization, it nevertheless appears certain that the form was more elongated longitudinally than in the majority of rays.

TRYGONIDAE.

Trygon muricatus (Volta).

1796. *Raja muricata* G. S. Volta, Ittiolit. Veronese, p. 37, Plate IX. Figs. 1, 2.
1818. *Trygonobatus vulgaris* H. D. de Blainville, Nouv. Dict. d'Hist. Nat. xxvii. p. 336.

1835. *Trygon gazzolae* L. Agassiz, Neues Jahrb., p. 297 (name only).
1839. *Trygon gazzolae* L. Agassiz, Poiss. Foss., iii. p. 382**; vol. iv. p. 38 (name only).
1851. *Trygon gazzolae* J. Heckel, Sitzungsber. Akad. Wiss. Wien, vii. p. 325.
1861. *Alexandrinum*, sp. R. Molin, Sitzungsber. Akad. Wiss. Wien, xlii. p. 579.
1874. *Alexandrinum molini* A. de Zigno, Mem. R. Istit. Veneto, xviii. p. 299, Pl. XII.
1874. *Trygon gazolae* A. de Zigno, Catalogo ragionato dei Pesci Fossili, p. 180.
1894. *Trygon* (*Taeniura*) *muricatus* O. Jaekel, Die eocänen Selachier vom Monte Bolca, p. 142, Plate IV. text-fig. 32.

One can gain some idea of the difficulties attending the identification and designation of this species from the following statements of Dr. Jaekel:

"Es ist auffallend, dass eine Form, die bereits von Volta vortrefflich beschrieben und abgebildet war, und welche durch ihren reich gegliederten Skeletbau so leicht kenntlich ist, so viele nachträgliche Benennungen erfahren hat. Volta kannte und beschrieb das hier Tafel IV abgebildete Exemplar der Collection Gazola; allerdings rechnete er zu der gleichen Art, die er als *Raja muricata* bezeichnete, noch ein mit einem Stachel besetztes Schwanzfragment (*l. c.* Taf. ix. Fig. 2), welches zu *Urolophus crassicauda* [*sic*] gehort. . . . Zu den späteren Benennungen gab z. Th. die Auffindung neuer Exemplare und die Nichtberücksichtigung des vorher beschriebenen Veranlassung. So enstanden auf Grund eines Exemplares in den Pariser Sammlung die Namen *Trygonobatus vulgaris* de Blainville und *Trygon Gazzolae* Agassiz, von welchen die letztere, obwohl er ohne Beschreibung veröffentlicht wurde, sich in der Litteratur am meisten einbürgerte. Dass Molin lediglich auf Grund der distalen Stellung des Schwanzstachels eine neue Gattung *Alexandrinum* aufstellte, . . . kann nicht gerechtfertigt erscheinen" (p. 142).

The above extract is in complete accord with the views of the present writer, save in one particular, which concerns the presence in this species of the form of caudal spine attributed to it by Volta. Heckel, and following him most writers, have maintained that the original of Volta's Pl. IX. Fig. 2 does not belong to *Trygon muricatus*, but to another form of ray altogether, that now known under the name of *Urolophus crassicaudatus* (Blv.). It is probable, however, that the same form of dermal defence is common to both species. As for the original of Volta's figure, either the identical specimen, or one so closely resembling it as to be indistinguishable from it, is preserved in the Paris Museum of Natural History; and this is seen very clearly to belong to a complete individual of *Trygon muricatus*.

Urolophus crassicaudatus (Blv.).

1818. *Trygonobatus crassicaudatus* H. d. de Blainville, Nouv. Dict. d'Hist. Nat. xxvii. p. 337.
1835. *Trygon oblongus* L. Agassiz, Neues Jahrb., p. 297.
Trygon oblongus L. Agassiz, Poiss. Foss., iii. p. 382, **, iv. p. 38.
1851. *Trygon brevicauda* J. Heckel, Sitzungsber. Akad. Wiss. Wien, vii. p. 324.
1853. *Urolophus princeps* J. Heckel, Sitzungsber. Akad. Wissen. Wien, xi. p. 122.

1861. *Taeniura kneri* R. Molin, Sitzungsber. Akad. Wiss. Wien, xlii. p. 581.
1863. *Urolophus princeps* Kner und Steindachner, Denkschr. Akad. Wiss. Wien, xxi. p. 32, Plate VI. Fig. 2.
1874. *Trygon oblongus* A. de Zigno, Catalogo Ragionato dei Pesci Fossili, p. 181.
1874. *Taeniura kneri* A. de Zigno, *ibid.*, p. 182.
1874. *Urolophus princeps* A. de Zigno, *ibid.*, p. 183.
1889. *Taeniura kneri* A. S. Woodward, Cat. Fossil Fishes Brit. Mus., pt. i. p. 153.
1894. *Urolophus crassicauda* O. Jaekel, Die eocänen Selachier vom Monte Bolca, p. 148, Plate V.

It seems desirable to give the complete synonymy of this species, as there is no possible reason for doubting that all of the rays described under the various names cited above belong to a single species. There is no specimen at the Paris Museum which can be certainly identified as the type either of de Blainville's *Tryyonobatus crassicaudatus*, or of Agassiz's *Trygon oblongus*.

CARCHARIIDAE.

Carcharias (Scoliodon) cuvieri (Agassiz).

(Text-figure *A*.)

1796. *Squalus carcharias* G. S. Volta, Ittiolit. Veronese, p. 10, Plate III. Fig. 1.
1807. *Squalus vulpes* Scortegagna, F. O., Memoria epistolare al Sig. Faujas-St.-Fond.
1807. *Squalus carcharias* G. Gazola, Lettera al Sig. Scortegagna, &c.
1818. *Squalus inmominatus* (*errore*) H. D. de Blainville, Nouv. Dict. d'Hist. Nat. xxviii. p. 336.
1835. *Galeus cuvieri* L. Agassiz, Neues Jahrb., p. 291.
1839. *Galeus cuvieri* L. Agassiz, Poiss. Foss., iv. p. 38.
1860. *Protogaleus minor* (*pars*) R. Molin, Sitzungsber. Akad. Wiss. Wien, xl. p. 583.
1874. *Alopiopsis cuvieri* (*pars*) A. de Zigno, Catalogo ragionato dei Pesci Fossili, p. 174.
1894. *Galeus cuvieri* O. Jaekel, Die eocänen Selachier vom Monte Bolca, p. 172, text-fig. 38.

The holotype of this species forms part of the Gazola Collection in Paris, and another specimen slightly smaller than the type is preserved in the University of Padua Museum. An outline figure of the latter is given by Jaekel, and likewise the following description: —

"Was nun schliesslich das kleinere, vorstehend abgebildete Exemplar der Paduaner Sammlung betrifft, so ist dasselbe fast vollständig erhalten, also wesentlich besser, als das von Volta abgebildete und von Agassiz als *Galeus cuvieri* bezeichnete. . . . Die Brustflossen sind schlank, fast sichelformig rückwarts gekrümmt."

Regarding the type-specimen in the Paris Museum the same author remarks that the rostral region is incompletely preserved, and "von den Flossen

sind nur die beiden Brustflossen deutlich." A little further on, however, he says: "Die erste Rückenflosse ist auch bei dem Pariser Exemplar an derselben Stelle angedeutet, wo sie bei dem hier abgebildeten sitzt, nämlich unmittelbar über dem Hinterrand der Brustflossen. Auch die zweite Dorsalis und die Analis scheinen bei dem Pariser Stück an der gleichen Körperstelle, wie an dem Paduaner, übereinander zu stehen. . . . Ueber die Form der Schuppen und sonstigen Einzelheiten konnte ich leider an dem Pariser Stück keine zuverlässige Beobachtung anstellen" (p. 174).

The present writer has not been able to verify the above description in all particulars, but on the other hand has found it possible to observe some details not previously made known.

The specimen, by the way, is preserved on a single slab, and the catalogue of the Museum does not show that it ever existed in counterpart, although the contrary is affirmed by Jaekel. The anterior third of the trunk lies squarely on its back in the matrix, the first dorsal fin being thus wholly or for the

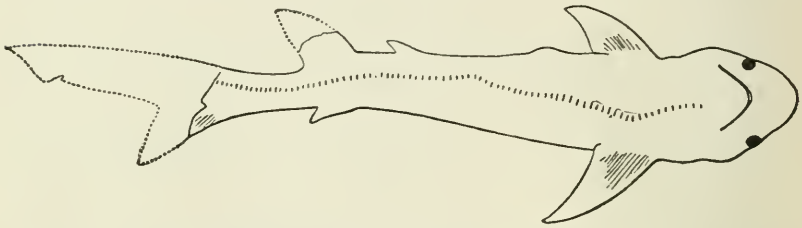

Fig. *A*. Type-specimen of *Carcharias* (*Scoliodon*) *cuvieri* (Ag.). × $\frac{1}{10}$. Extremities of the dorsal and caudal fins hypothetically restored.

most part concealed. The remainder of the trunk is visible from the lateral aspect, and the fins which it exhibits are the posterior dorsal, anal, and a portion of the lower lobe of the caudal, as indicated in the accompanying Figure *A*. A small triangular mass of scales lying immediately in front of the posterior dorsal may perhaps be interpreted as a ruptured portion of the shagreen, or possibly even as the displaced tip of the anterior dorsal.

The shagreen is very excellently preserved over various portions of the body, the form and structure of the individual scales appearing as distinct as in life. The shagreen granules agree so perfectly with those of the recent Scoliodon that no further description is necessary, and the same is true of the dentition. A number of the teeth are preserved in their natural position in the mouth region, and all exhibit very clearly the inclined triangular crown with smooth edges characteristic of Scoliodon. It will be seen that the identification which is here made of this shark as a species of Scoliodon is in accordance with all the characters, except that the rostrum appears to have been rather less prolonged. In the above text-figure, the posterior dorsal and caudal fins have been hypothetically restored.

Altogether seventeen species of elasmobranchs are known from the Monte Bolca horizon, a list of which is subjoined:

Species of Elasmobranchs from Monte Bolca.

1. *Rhinobatis zignii* (Heckel).
2. " *primaevus* Zigno.
3. *Platyrhina bolcensis* (Heckel).
4. " *egertoni* Zigno.
5. " *gigantea* (Blv.).
6. *Narcine molini* Jaekel.
7. *Trygon muricatus* (Volta).
8. " *zignii* (Molin).
9. *Urolophus crassicaudatus* (Blv.).
10. *Promyliobatis gazolae* (Zigno).
11. *Lamna vincenti* Winkler.
12. *Odontaspis hopei* Ag.
13. *Carcharodon auriculatus* (Blv.).
14. *Pseudogaleus voltai* Jaekel.
15. *Alopiopsis plejodon* Lioy.
16. *Carcharias (Scoliodon) cuvieri* (Ag.).
17. *Mesiteia emiliae* Kramb.

TELEOSTOMI.

ACTINOPTERYGII.

ALBULIDAE.

MONOPTERUS Volta.

Trunk elongated oval and laterally compressed. Head relatively short, with steep frontal profile; opercular bones well developed. Vertebrae at least 60 in number, half of them being caudal. Length of anterior pectoral fin-ray exceeding maximum depth of trunk; pelvic fins minute, situated nearer the anal than the pectoral pair. Anal placed opposite the dorsal, and rising into an acuminate lobe in front. Caudal very deeply forked, with a scaly lamella extending over the middle of the tail at the base. Mouth opening small, a series of conical teeth present along the margin of the jaws, and a series of hemispherical crushing teeth placed further back.

Monopterus gigas Volta.

1796. *Monopteros gigas* G. S. Volta, Ittiolit. Veronese, p. 191, Plate XLVII.
1818. *Monopteros gigas* H. D. de Blainville, Nouv. Dict. d'Hist. Nat., xxvii. p. 357.
1835. *Platinx gigas* L. Agassiz, Neues Jahrb., p. 304.
1838–44. *Platinx gigas* L. Agassiz, Poiss. Foss., v. pt. 2, p. 126.
1874. *Platinx gigas* A. de Zigno, Catalogo ragionato dei Pesci Fossili, p. 151.

The removal of this species from the genus Platinx, and its transfer to the vicinity of Chanos, amongst the Albulidae, appears warranted by the presence of numerous hemispherical crushing teeth in the pharyngeal region, and by the

structure of the caudal and other fins. The dorsal and anal are situated opposite each other, and consist each of 20 rays. The caudal is short and much expanded, covered with a scaly lamella along the middle at its base, and the distance between the extremities of its lobes exceeds the maximum depth of the trunk. All of the fins have the foremost ray covered with a finely rugose dermal layer, and the anterior pectoral fin-ray is as much enlarged and elongated as in certain Osteoglossidae and Chirocentridae. This species, of which several examples are known, attains a total length of about 80 cm.

SCOPELIDAE.

Holosteus esocinus Agassiz.

1838-44. *Holosteus esocinus* L. Agassiz, Poiss. Foss., v. pt. 2, p. 85, Plate XLIII. Fig. 5.

1856. *Holosteus esocinus* H. G. Bronn, Lethaea Geognostica, p. 683, Plate XLII.[3] Fig. 8.

1874. *Holosteus esocinus* A. de Zigno, Catalogo ragionato dei Pesci Fossili, p. 140.

The holotype and only known example of this species is an imperfectly preserved fish belonging to the Gazola Collection of the Paris Museum. It bears on the reverse the following MS. inscription in Agassiz's handwriting: "Cette plaque est évidemment composée de pièces incoherentes, surtout de la partie antérienre de la dorsale, et vers le front de la tête; cependant la colonne vertebrale indique un poisson d'un genre nouveau voisin de *Belone*."

An examination of the specimen shows that the vertebral column is intact from the occiput at least as far as the insertion of the dorsal fin, the latter being unquestionably preserved in its natural position. It is evident that the triangular piece intended to represent the interneurals supporting the dorsal does not belong to this fish, and the same remark applies also to another fragment introduced in advance of the dorsal, which was properly recognized by Agassiz as "n'étant q'une fausse dorsale." Although the authenticity of the anal itself is doubtful, its position is shown by the presence of fin-supports to be opposite the dorsal. Very little of the portion posterior to the anal fin can be regarded as other than a factitious mosaic.

CARANGIDAE.

Caranx primaevus, sp. nov.

(Plate 1, Fig. 4; Text-fig. *B*.)

A small species attaining a total length of about 10 cm. Head with opercular apparatus contained slightly less than $3\frac{1}{2}$ times in the total length to base of caudal fin. Trunk laterally compressed, elongated, regularly fusiform. An-

terior dorsal fin with about 8 spines of moderate length, closely followed by the low second dorsal with about 20 soft rays. Anal fin opposed to the posterior dorsal, and apparently of equal extent, preceded by two short and separate anal spines. Dorsal and anal finlets not observed. Scales thin and small. Lateral line with well-developed scutes along its entire length, the line arching upward and the scutes becoming shorter anteriorly; number of scutes about 65.

The unique individual upon which the above description is based exists in counterpart, and details taken from both halves have been combined in

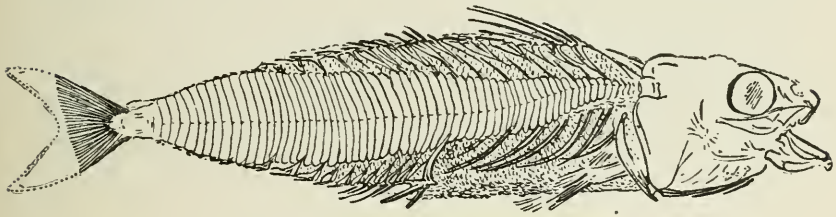

FIG. *B.* *Caranx primaevus*, sp. nov. × ½.

the adjoining Figure *B.* This is the earliest recorded appearance of the genus in geological history, the half-dozen fossil species that are known being confined to the Oligocene and Miocene. Amongst the latter *C. ovalis*, which is imperfectly known, seems to have resembled the present species in general outline, and amongst modern forms the species commonly referred to "*Trachurus*" (e.g., *Caranx trachurus* and *C. picturatus*) present the same peculiarity of having scutes developed along the entire length of the lateral line.

The type-specimen, which is from Monte Bolca, is preserved in the Museum of Comparative Zoölogy.

LABRIDAE.

Symphodus szajnochae (ZIGNO).

(Plate 1, Fig. 5.)

1887. *Crenilabrus szajnochae* A. de Zigno, Mem. R. Istit. Veneto, xxiii. p. 17, Fig. 3.

Besides the holotype of this species, which is small and imperfectly preserved, no other examples have come to light until recently, when one was acquired for the Museum of Comparative Zoölogy, and another for the Carnegie Museum at Pittsburgh. The individual belonging to the Cambridge collection is preserved in counterpart, and is interesting for the additional information which it affords in regard to certain structural details.

This example has a total length of 10 cm. to the base of the caudal fin, and in this distance the head with opercular apparatus is contained four times.

The preoperculum is strongly serrated, its posterior border being produced into very prominent spines. The marginal teeth are conical and arranged in single series, no pharyngeal teeth being observed. The vertebrae are about 25 in number, of which 14 are caudal. The dorsal fin is much extended, with about 26 rays, and of these 11 are spinous. The caudal is composed of 17 principal rays, there being one more in the upper than in the lower lobe, and these are preceded both above and below by four or five spinelets. The anal appears to be formed of about eight rays in addition to the spines, but their number cannot be accurately counted. There are at least eight branchiostegal rays. Evidence of the former extension of the scales over the opercular bones and cheeks is not apparent in the present condition of the specimen, nor in fact is it ordinarily to be expected amongst fossils. The scales are thin, ctenoidal, and very strongly pectinated.

Crenilabrus was separated by Cuvier from Labrus as a distinct genus on account of its having a serrated preoperculum, but it has been shown by D. S. Jordan in his Review of Labroid Fishes [1] that the form is identical with the earlier described Symphodus of Rafinesque.

CHAETODONTIDAE.

PYGAEUS Agassiz.

To this imperfectly known extinct genus have been referred half a dozen species from the Bolca Eocene, and two from the Lower Miocene of Chiavon, Vicentin. The type species is *P. bolcanus* (Volta), renamed *P. gigas* by Agassiz. This is a large form, attaining a total length of about 35 cm., the remaining species being very much smaller, and included by Agassiz only provisionally in the same genus with the type. It appeared to Agassiz that the smaller forms constituted a group by themselves, typified by *P. coleanus*, but passing over into the group of larger forms through the intermediate *P. oblongus*. Concerning the advisability of subdividing the genus, Agassiz remarks as follows: "Il faudra donc probablement démembrer un jour ces espèces et en faire autant des genres qu'on y reconnaîtra de types differents, en les étudiant d'une manière plus complète; ce qui sera d'autant plus difficile que les Pygées sont fort rares dans les collections."

There are in addition to the small number of forms known to Agassiz two other species represented by a solitary individual each, which are evidently closely akin to *Pygaeus bolcanus*, although possessing more finely divided vertical fins. These are the so-called *Acanthurus gazolae* Massalongo [2] and *A. gaudryi* de Zigno,[3] from the Bolca Eocene, whose true position amongst

[1] Jordan, D. S., A Review of the Labroid Fishes of America and Europe, Rept. U. S. Fish Comm. for 1887, pp. 559–699, 1891.

[2] Specimen Photogr. Anim. Foss. Agr. Veron., 1859, p. 26.

[3] Atti R. Istit. Veneto, xxiii. 1887, p. 14, Fig. 2.

Chaetodonts has already been suspected by Smith Woodward. It is probable that they represent types of distinct genera, but for the present they may be most conveniently included within the limits of Pygaeus, as purposely extended by Agassiz. It is evident that some of these forms are closely related to modern Acanthuridae, the chief differences consisting in the great development of the dorsal spines, and the fact that the maxilla and premaxilla are distinct. The latter condition is alone sufficient to warrant the retention of these larger species of Pygaeus amongst the Chaetodontidae, rather than amongst the Acanthuridae, or so-called "Acronuridae" of Günther, and Teuthidae of Jordan. On the other hand, the teeth are much stouter than in living Chaetodonts.

We have now to offer the description of a new species of Pygaeus, as construed in its broader sense, no division of this genus being at present attempted.[1] The type-specimen formerly belonged to the Marchese di Canossa Collection, a part of which was purchased some months ago for the Museum of Comparative Zoölogy. The choice of a specific title has been determined by the desire to commemorate the labors of the master in this field, his name not being similarly associated with any other member of the Bolca fauna.

Pygaeus agassizii, sp. nov.

(Plate 2.)

D. 10 + 9; A. 5 + 8; V. 5; P. 17 or 18.

A comparatively large species, attaining a total length of about 19 cm. Maximum depth of trunk contained twice, and length of head with opercular apparatus three times in the total length to base of caudal fin. Dorsal fin arising immediately behind the occiput and extending as far as the caudal peduncle with ten subequal spines and nine articulated rays, the latter not longer than the former, and not produced into an acute lobe in front. Anal spines gradually increasing in length and stoutness from the first onward, the fifth equalling the foremost articulated ray in length, and longitudinally striated. Articulated portion of the anal corresponding in size and position to the articulated dorsal. Abdominal vertebrae 10, caudal 13. Large incisiform teeth present in front, gradually diminishing in size posteriorly, apparently in single series; maxilla and premaxilla clearly separate. Scales small, those of the posterior part of the body in the form of shagreen-like calcifications and tubercles. Neural spines of abdominal region and all of the interspinous bones much expanded; pelvic bones strongly developed. No lateral caudal spines.

[1] The writer is indebted to President Jordan, than whom is no higher authority, for the suggestion that "*Pygaeus*, and possibly *Apostasis* also, should be taken as representing a distinct family, which would occupy a more central position near the common ancestry of *Acanthuridae Chaetodontidae*, and *Siganus* (*Teuthis*)" (*litt.*, May, 1904).

The general outline of body in this species is more suggestive of Acanthurus than Pygaeus, but the fin-structure is wholly in accord with the latter genus. The development of the spinous dorsal is about equal to that of the type species of Pygaeus, but the articulated dorsal is less strongly developed. This is a character of specific importance, and its variation amongst different forms belonging to the same general group is indicated by the following formulae :

Pygaeus bolcanus	D. 10 or 12 + 20 (*fide* Agassiz).
" *agassizii*	D. 10 + 9; A. 5 + 8.
" *nobilis*	D. 12 + 12; A. 3 + 12.
" *coleanus*	D. 14 + 15; A. 9 + 11.
Acanthurus gaudryi	D. 7 + 28; A. 3 + 25.
" *tenuis*	D. 9 + 21; A. 3 + 19.

LOPHIIDAE.

Histionotophorus, nomen nov.

[*Histiocephalus* A. de Zigno, 1887.]

The name proposed for this genus by Baron de Zigno is not only inappropriate but preoccupied, Diesing having applied it to a genus of Vermes in 1851. The title Histiocephalus may therefore be discarded in favor of *Histionotophorus*, which is bestowed in allusion to the sail-like median fin extending along the back.

Histionotophorus bassani (Zigno).

(Plate 1, Figs. 1-3; Text-fig. C.)

1887. *Histiocephalus bassani* A. de Zigno, Mem. R. Istit. Veneto, xxiii. p. 31, Fig. 9.

D. I – I – I + 13; C. 8; A. 9; V. 7; P. 6.

A comparatively small pediculate species attaining a total length to the base of the caudal fin of about 6 cm. Mouth oblique, maxillary extending far downward, dentary thickened, jaws with cardiform teeth, skin naked. Anterior dorsal of three separated tentacle-like spines on the head, posterior dorsal high, much extended, with thirteen articulated rays, the fin-membrane stiffened at the base with small spiniform calcifications. Pectoral members situated immediately above the origin of the anal fin, their short rays directed vertically, and supported by extremely long pseudobrachia, which are apparently composed of two actinosts. Number of vertebrae apparently not more than 18 (according to de Zigno, however, there are 22 in the type, 10 abdominal and 12 caudal).

Three specimens answering to the above description, two of them in counterpart, are preserved in the Museum of Comparative Zoölogy, and their princi-

pal characters are combined in the accompanying text-figure, so far as they are observable. There is little room for doubt that these interesting and rare pediculates are identical with the species described by Baron de Zigno under the name of *Histiocephalus bassani*, although the type-specimen is so imperfectly preserved that his description is at variance in some points with the one given above, and the affinities of the type have remained more or less obscure. The latter, indeed, was referred to the Scorpaenidae by Dr. A. S. Woodward in his Catalogue of Fossil Fishes in the British Museum. The characteristic pectoral members are not shown in de Zigno's illustration of this form, and the head is much disfigured; as for a supposed membrane supported by the cephalic spines (to which the name Histiocephalus alludes), no indication is afforded by the new material that such a structure existed. An interesting fact to be noted is the close correspondence existing between the fin-formulae of the fossil and recent species. In the common Angler, *Lophius*

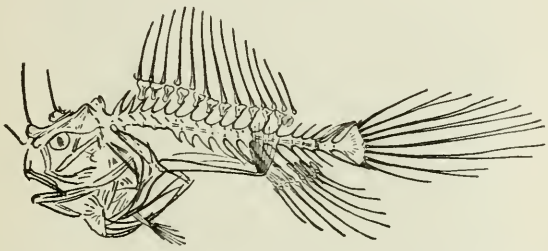

FIG. C. *Histionotophorus bassani* (de Zigno). × $\frac{1}{1}$ A composite drawing based upon three individuals belonging to the Mus. Comp. Zoöl.

piscatorius, for instance, as well as in the form under discussion, the first and second dorsal together comprise 13 rays, and the number of rays belonging to the caudal, anal, and ventral fins is identical in both species.

It is to be regretted that the cranial osteology is not more clearly displayed, as it would be interesting to compare the various degrees of modification exhibited by the Eocene and modern pediculates. The recent genus Corynolophus exhibits a similar thickening of the dentary and other bones of the lower jaw, and another resemblance is seen in the construction of the premaxillaries, which are probably movable, but further than this we cannot go. Attention should be called, however, to the remarkable fact of a type of fish-life appearing suddenly in the Eocene, already highly modified, without any known predecessors nor any that can be plausibly conjectured, but which persists after its first introduction essentially unchanged until modern times.

GYMNODONTIDAE.

Diodon erinaceus Agassiz.

(Text-figure *D.*)

1844. *Diodon erinaceus* L. Agassiz, Poiss. Foss., ii. pt. ii. p. 274.
1859. *Diodon erinaceus* A. B. Massalongo, Specimen Photogr. Anim. Foss. Agr. Veron., p. 21, Plate XII. Fig. 2.
1874. *Diodon erinaceus* A. de Zigno, Catalogo ragionato dei Pesci Fossili, p. 163.
1876. *Diodon erinaceus* F. Bassani, Atti Soc. Veneto-Trent. Sci. Nat., iii. p. 189.
1901. *Diodon erinaceus* A. S. Woodward, Cat. Foss. Fishes Brit. Mus., pt. iv. p. 572.

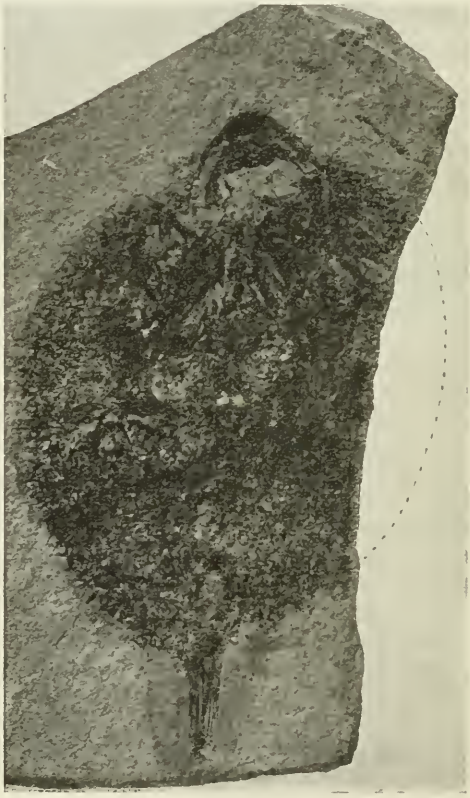

Fig. *D.* *Diodon erinaceus* Ag. × $\frac{1}{1}$.

This species has never been satisfactorily defined, and with the extremely limited material that has thus far been obtained, a precise definition is not yet

possible. Agassiz's sole description consists in the statement that it is "une espèce de trois pouces de long, remarquable par sa forme ovale et par ses piquants courts, robustes et assez clair-semés." Of the type-specimen, now preserved in the British Museum, Dr. Woodward states that it is exposed from the ventral aspect, has the dentition much obscured, and "no fins are seen except part of the caudal. The largest and most slender spines are at the sides of the middle of the trunk."

The type-specimen has never been figured, and the species is so little known that it seems desirable to furnish an illustration of a specimen closely resembling the type, which has recently been secured by the Museum of Comparative Zoölogy. This is shown from the ventral aspect in the adjoining text-figure 4, and it will be seen that scarcely any differences are to be noted between it and the so-called "*Enneodon echinus*" of Heckel. In the latter, according to this author, "der Oberkiefer ist mit sieben kleinen Zahnplatten besetzt, die gleich einer Reihe flacher Schneidezähne dicht an einander stehen." There are some obscure indications that separate teeth were also present around the margin of the upper jaw in *Diodon erinaceus*, but as this cannot be absolutely demonstrated at present, it is not deemed advisable to unite these two species. The lower dental plate is well shown from the inferior aspect in the Cambridge specimen, and does not appear to have been divided by a median longitudinal suture. Pelvic fins are not observable, nor has the writer been able to detect them in any specimen of *D. tenuispinus* from Monte Bolca thus far examined by him. An example of this species so closely resembling the type as to have been confused with it by some writers is treasured amongst the splendid collection belonging to the Paris Museum of Natural History. For the exceptional favors and facilities enjoyed at the hands of M. Albert Gaudry and M. Boule during his study of this collection the past year, the writer finds it difficult to express his deep sense of obligation and gratitude.

EXPLANATION OF PLATES.

All figures are of the natural size, and the originals are preserved in the Museum of Comparative Zoölogy.

PLATE 1.

Figs. 1–3. *Histionotophorus bassani* (Zigno). Upper Eocene; Monte Bolca. Figs. 1 and 1 *a* are counterparts of the same specimen.
Fig. 4. *Caranx primaevus*, sp. nov. Upper Eocene; Monte Bolca.
Fig. 5. *Symphodus szajnochae* (Zigno). Upper Eocene; Monte Bolca.

PLATE 2.

Pygaeus agassizii, sp. nov. Upper Eocene; Monte Bolca (*ex* Canossa Collection).